Teaching Kinetic Molecular Theory, OUTSIDE!

This lesson outline will guide you in the implementation of an outdoor activity to teach your students the properties of solids as defined by molecular movement and Kinetic Molecular Theory and how it relates to the way that we understand gases.

**Materials:**

* Marbles (see Variation)
* Pieces of Chart Paper/Bristol board with postulates written down (as later described)
* ENERGY! (get students running around, not just walking – if you aren’t energized for this demo, it will not work!)
* Rope and/or pylons (for boundaries if no natural barriers exist)
* Whistle (to get students attention – or just yell)
* **TELL STUDENTS THE PREVIOUS CLASS THAT TODAY THEY WILL BE RUNNING AROUND OUTSIDE AND TO WEAR COMFORTABLE FOOTWEAR AND CLOTHING SUITABLE FOR THE WEATHER**

**Safety and Other Considerations**

* Students may get a little TOO excited running and bumping into each other. If this becomes the case, you can ‘freeze’ those molecules temporarily, or conversely tell students that they can have fun bumping into each other, but that there is not to be a loss of kinetic energy aka no student can fall down or get hurt.
* Some students may not feel comfortable running outside and may get short of breath or tired before other students. Allow a space for students who want to ‘observe’. Some students may also not feel comfortable bumping into each other and you should make it clear from the start that any violence or improper touching is not allowed. – allow students the RIGHT TO PASS
* If you have students bumping into each other, have them do it ‘shoulder-to-shoulder’ and LIGHTLY! If not, revert to the Variation
* **Variation:** All of the activities described are instead performed by students holding marbles. All collisions and movement is represented by students moving and by marbles colliding.

**The Lesson**

1. Bring students outside and set up a defined perimeter using natural barriers or the rope and pylons.
2. Instruct your students that this will be the ‘walls of the container’
3. Remind student about the three types of particle movement
   1. Have them demonstrate these (vibrational, rotational translational)
   2. Ask which types of motion are demonstrated by which states of matter (vibrational/rotational in solids/liquids, all three in gases)
4. Tell students that they are all particles within this container. Each of them is a molecule or an atom, but they are all particles. Have them show what sorts of motion they can do as particles.
5. Instruct students to form a solid (using all particles)
   1. They should all congregate together, remind them of the crystalline structure and have them holding hands with each other
   2. They should not be standing still, they should be buzzing, vibrating, and rotating
6. Instruct students to form a liquid
   1. There should be more movement between particles now. Students should not be holding hands but should be still relatively close to one another, moving around each other.
      1. Ask them what is different between this and the previous states.
7. Tell students that they are free to move around the container as they like, however they think a gas moves. Give them a few minutes to do so. They must walk or around.
   1. Ask them why they are behaving this way.
8. Tell them that you are going to start introducing the kinetic molecular theory to this mix, postulate by postulate (explain postulate = assumption)
   1. Ask why we use KMT?
9. Have them start moving – tell them to speed up
10. As you introduce postulates, call the entire group together, show them written out on chart paper/Bristol board. Have them repeat the postulate aloud. Ask students how they think their motion could change
11. POSTULATE 1: ***Gases consist of large numbers of tiny particles that are far apart relative to their own size. –***
    1. Have students get really really far apart but keep moving around and bouncing around
12. POSTULATE 2: ***There are no forces of attraction or repulsion between gas particles.***
    1. Instruct students that they may no longer congregate with their friends or avoid certain people (especially the smelly teacher!) they must bounce around randomly
13. POSTULATE 3: ***Gas particles move continuously, rapidly, and randomly in straight lines in all directions.***
    1. Instruct students that they may only move in straight lines and must only change direction upon collision with other students.
14. POSTULATE 4: **All collisions between particles and each other or the container are considered to be elastic collisions (no loss of kinetic energy)**
    1. When students hit each other, they must bounce off right away and not lose energy (aka keep moving in a diff direction at the same speed)
15. POSTULATE 5: ***The average kinetic energy depends on the temperature of the gas (directly increases with temperature increase)***
    1. Tell students that you are the chemist and now you will be changing the temperature of the container. Tell them their starting temperature then start calling out other temperatures and have them respond accordingly.
16. Make sure all students are following all the laws
17. Bring all students back to you. Have students go over the postulates as a group and discuss if they were actually following all of these. Facilitate the discussion of how can we improve our model (considering the postualtes).
18. Make students refine their model to be more accurate (post discussion)
19. Pack up materials, go back inside for the rest of the debrief!